Improving the performance of a receiver in interfering conditions

FIELD OF THE INVENTION

The invention relates to a device comprising a receiver for receiving and processing signals and an antenna which is connected to the receiver. The invention relates equally to a method for improving the performance of such a receiver.

BACKGROUND OF THE INVENTION

Receivers for receiving and processing signals are well known in the art, for example in form of a GPS (Global Positioning System) receiver of a GPS system.

The performance of a receiver may be degraded during time intervals in which wideband noise in the frequency band used for the signals which are to be received by the receiver is present in the environment of the device, since this wideband noise may reduce the signal-to-noise ratio (SNR) of the received signals significantly.

The wideband noise can be generated in particular by a communication system transmitter integrated in the same device as the receiver, or by a nearby communication system transmitter external to this device. Such an internal or external communication system transmitter can be for instance part of a GSM (Global System for Mobile communications) transceiver, of a CDMA (Code Division

Multiple Access) transceiver, of a US-TDMA transceiver
or of a WCDMA (Wideband CDMA) transceiver.

In a GPS system, for example, several GPS satellites that
orbit the earth transmit signals which are received and
evaluated by GPS receivers. All GPS satellites use the
same two carrier frequencies L1 and L2 of 1575.42 MHz and
1227.60 MHz, respectively. GPS signaling is based on a
CDMA principle, i.e. the satellites and their signals are
separated by the codes used to modulate the two carrier
signals. The employed carrier modulation is a BPSK (bi-
phase shift key) modulation, in which the carrier
frequency phase is shifted by 180 degrees every time a
chip changes from zero to one or vice versa.

The modulation of the carrier frequencies L1 and L2 is
illustrated in figure 1. After a phase shift of 90
degrees, the sinusoidal L1 carrier signal is BPSK
modulated by each satellite with a different C/A (Coarse
Acquisition) code known at the receivers. Thus, different
channels are obtained for the transmission by the
different satellites. The C/A code, which is spreading
the spectrum over a 1.023 MHz bandwidth, is a
pseudorandom noise sequence which is repeated every 1023
chips, the epoch of the code being 1 ms. The term chips
is used to distinguish the bits of a modulation code from
data bits.

In parallel, the L1 carrier signal is BPSK modulated
after an attenuation by 3dB with a P-code (Precision
code), and the L2 carrier signal is BPSK modulated with
the same P-code before an attenuation by 6dB. Before
transmission, the two differently modulated parts of the

L1 carrier signal are summed again. The L2 carrier signal
carries currently only the P-code. The P-code is much
longer than the C/A code. Its chip rate is 10.23 MHz and
it repeats every 7 days. In addition, the P-code is
currently encrypted, and for that reason it is often
referred to as P(Y)-code. Decryption keys needed for
using the P(Y)-code are classified and civil users cannot
access them. Therefore, only the L1 carrier C/A code is
usable in civil GPS receivers.

Before the C/A code and the P(Y)-code are modulated onto
the L1 signal and the L2 signal, navigation data bits are
added to the C/A and P(Y)-codes by using a modulo-2
addition with a bit rate of 50 bits/s. The navigation
information, which constitutes a data sequence, can be
evaluated for example for determining the position of the
respective receiver. The navigation information comprises
e.g. precise satellite orbital parameters and clock
correction parameters. When a receiver is able to
despread a received signal based on the correct
modulation code, it can extract and evaluate the
navigation data. A GPS signal which is received at a GPS
receiver is further modulated due to the Doppler effect
and possibly due other higher order dynamic stresses.

The reception bandwidth of a GPS receiver receiving the
modulated satellite signals is related to the reception
code. For example, if GPS is based on the L1 carrier C/A
code, then the signal requires a frequency band of
1575.42 MHz +/-5 MHz. If a P-code capable receiver is
used, then the reception band of the GPS receiver is much
wider, it is likely to be 1575.42 MHz +/-24MHz. The
actual used GPS reception bandwidth is further related to

the actual implementation, and thus the previously
mentioned bandwidths are presented for demonstration
purposes. The mentioned GPS bandwidth will thus be used
in the following only by way of example.

The GPS standard is currently under modernization. One of
the main components of the modernization consists in two
new navigation signals that will be available for civil
use in addition to the existing civilian service
broadcast of the L1-C/A code at 1575.42 MHz.

The first one of these new signals will be a C/A code
located at 1227.60 MHz, i.e. modulated onto the L2
carrier frequency, and will be available for general use
in non-safety critical applications. The new civilian
signal at L2, referred to as "L2CS", will generally be
characterized by a 1.023 Mcps (mega chips per second)
effective ranging code having a Time Division Multiplex
of two 1/2 rate codes. The L2CS signal will be BPSK
modulated onto the L2 carrier, along with the P(Y)-code.
This C/A code will be available beginning with the
initial GPS Block IIF satellite scheduled for launch in
2003.

The second one of the new signals will be using a third
carrier frequency L5 located at 1176.45 MHz. The L5
carrier frequency will be modulated with C/A codes, more
specifically with a CL code of 767,250 chips and a CM
code of 10,230 chips. The L5 signal will provide a 10.23
Mcps ranging code, wherein it is expected that improved
cross correlation properties will be realized. The L5
signal will be message based. It will include an I (In-
phase) channel carrying 10-symbol Neumann/Hoffman

encoding and a Q (Quadrature) channel carrying 20-symbol Neumann/Hoffman encoding. The I and Q channels will be orthogonally modulated onto the L5 carrier. The L5 signal falls into a frequency band which is protected worldwide for aeronautical radionavigation, and therefore it will be protected for safety-of-life applications.
Additionally, it will not cause any interference to existing systems. Thus, with no modification of existing systems, the addition of the L5 signal will make GPS a more robust radionavigation service for many aviation applications, as well as for all ground-based users, like maritime, railways, surface, shipping, etc. The L5 signal will provide significant benefits above and beyond the capabilities of the current GPS constellation, even after the planned second civil frequency L2 becomes available. Benefits include precision approach navigation worldwide, increased availability of precision navigation operations in certain areas of the world, and interference mitigation. The new L5 signal will be available on GPS Block IIF satellites scheduled for launch beginning in 2005.

At the current GPS satellite replenishment rate, all three civil signals, i.e. L1-C/A, L2-C/A and L5, will be available for initial operational capability by 2010, and for full operational capability approximately by 2013.

In particular communication systems operating in the 1900 band, like GSM1900, which are widely referred to as PCS (Personal Communication System), and communication systems operating in the 1800 band, like GSM1800, which are widely referred to as DCS (Digital Communication System), will generate wideband noise in this GPS L1 band

of 1575.42 MHz +/-5 MHz, when C/A code supported GPS is used. When new L2 and L5 frequency GPS signals are used, then lower frequency GSM signals, i.e. GSM900 and GSM800, will generate the same wide band noise problem as GSM1800 to the L1 GPS signal.

Measurements show that if no measures are taken, the SNR of a GPS signal received by a GPS receiver degrades by about 2dB in case a GSM transmitter implemented in the same device uses for transmissions a single slot TX (transmission) mode, and by about 3dB in case the GSM transceiver implemented in the same device uses for transmissions a dual slot TX mode.

The GPS receiver, however, requires a sufficient SNR of received satellite signals for being able to correctly acquire and track the signal based on its C/A-code and thus to make use of its content. It is better for the performance of the GPS receiver to receive signals with a particularly low SNR than not to receive any signal at all during short time intervals.

Typically in spread spectrum systems, the AGC (Automatic Gain Control) tunes the received information signal level for A/D (analog to digital) conversion based on the noise level. In normal operation conditions, the noise is coming from background noise, which has a constant power level. The problem arises when the noise level rises rapidly and the AGC tries to adjust an incoming signal to a certain appropriate level for an A/D conversion. A fast varying high noise level can cause saturation in the A/D converter and the amplitude of the signal is clipped. If the signal is clipped in conversion, some information

signal is lost and thus the receiver performance is degraded.

Also external interferences can block a GPS receiver operation completely, in case multiple communication system transmitters are transmitting in the same area at the same time.

The same problem may further occur when a Galileo receiver is used instead of a GPS receiver. Galileo is a European satellite positioning system, for which the beginning of commercial operations is scheduled for 2008. Galileo comprises 30 satellites, which are distributed to three circular orbits to cover the entire surface of the Earth. The satellites will further be supported by a worldwide network of ground stations. It is planned that Galileo will provide ten navigation signals in Right Hand Circular Polarization (RHCP) in the frequency ranges 1164-1215 MHz, using carrier signals E5a and E5b, 1215-1300 MHz, using a carrier signal E6, and 1559-1592 MHz, using a carrier signal E2-L1-E1. Similarly as with GPS, the carrier frequencies E5a, E5b, E6 and E2-L1-E1 will be modulated by each satellite with several PRN codes spreading the spectrum and with data. Thus, GSM transmitters may equally generate wideband interferences in frequency bands employed by Galileo.

Obviously, the performance of a receiver due to transmissions by a communication system transmitter may equally be degraded in a similar situation in case of another type of a communication system transmitter than a GSM transmitter and/or another type of a receiver than a GPS receiver or a Galileo receiver.

In U.S. patent no. 6,107,960, a method is proposed for
reducing cross-interferences in a combined satellite
positioning system receiver and communication system
transceiver device. A control signal is transmitted from
the communication system transceiver to the satellite
positioning system receiver, when the communication
transceiver transmits data at a high power level over a
communication link. The control signal causes the
satellite positioning system signals from satellites to
be blocked from the receiving circuits of the satellite
positioning system receiver, or to be disregarded by the
processing circuits of the satellite positioning system
receiver.

For a communication system transmitter which is combined
in a single device with the satellite positioning system
receiver, it has further been proposed to improve the SNR
of received satellite signals by adding an external
notch-filter to the transmission path of the
communication system transmitter. The notch filter, which
is arranged after a power amplifier in the transmission
path, has a passband frequency range for passing on the
frequencies required for the communication system, and a
stop band frequency range for attenuating the frequencies
required for the satellite positioning system.

For PCS and DCS, the passband frequency range of the
notch filter has to be 1710 MHz to 1910 MHz, and in case
GPS is used as satellite positioning system, the stop
band frequency range has to be 1558.42 MHz to 1580.43
MHz. In order to improve the SNR of received GPS signals
to a useful level, a very high attenuation is required

for the stop band. Applying a high attenuation, however,
increases also the insertion loss of the notch filter at
the pass band of the filter. Due to this additional loss
after the power amplifier, more output power has to be
taken from the power amplifier, which increases the
current consumption.

Measurements show that an antenna isolation of about 10dB
is required for single slot GSM, if the GPS SNR is to be
improved to a desired level of 0.5dB degradation. To a
GSM1800 transmission path, a 30dB external GPS band
attenuator has to be added for achieving the same desired
level of 0.5dB degradation. For dual slot GSM, the
required attenuation is even higher.

The insertion loss of a GPS notch-filter with a 30dB GPS
band attenuation will lie between 0.7dB and 1.0dB. An
insertion loss between 0.7dB and 1.0dB increases the
current consumption of the power amplifier by about 20%,
compared to a current consumption without insertion loss.

It is thus a disadvantage of the approach using a notch-
filter that an extra component is needed in the
communication system transmitter and that the power
amplifier current consumption increases about 20%, which
also results in an increased heating of the device. On
the whole, the costs for improving the GPS SNR by only
about 1.5dB are high.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an
alternative to existing solutions for improving the
performance of a receiver in interfering conditions.

On the one hand, a device is proposed, which comprises a
receiver for receiving and processing signals at least in
a first frequency band, and at least a first antenna
which is connected to the receiver. The proposed device
further comprises a tuning component for shifting a
frequency response of the first antenna from the first
frequency band to a second frequency band. The tuning
component may include for instance a capacitance diode,
but equally or any other suitable components. Moreover,
the proposed device comprises a controlling portion
causing the tuning component to shift the frequency
response of the antenna from the first frequency band to
the second frequency band, in case a wideband noise is
expected in the first frequency band.

On the other hand, a method for improving the performance
of a receiver is proposed. The receiver is able to
receive and process signals at least in a first frequency
band, and it is connected to at least a first antenna.
The proposed method comprises as a first step determining
whether a wideband noise is expected in the first
frequency band. The proposed method comprises as a second
step shifting a frequency response of the first antenna
from the first frequency band to a second frequency band,
in case a wideband noise is determined to be expected in
the first frequency band.

The invention proceeds from the consideration that some
receivers, like GPS receivers, have severe problems in

coping with high noise levels. It is therefore proposed
that when wideband noise is generated in the frequency
band employed for the signals which are to be received by
the receiver, the antenna is detuned out of the regular
center frequency. As a result, the wideband noise cannot
be received any more via the antenna and does thus not
disturb the receiver.

It is an advantage of the invention that it provides an
alternative to existing solutions.

When detuning the antenna, also the received signal is
attenuated. If the received signal is weak, the
attenuation causes that the signal cannot be detected.
However, if the signal is strong, it may be possible to
detect the signal in spite of the attenuation. This
constitutes an advantage compared to the solution
proposed in the above cited document US 6,107,960, as
here, the blocking or disregarding of satellite signals
affects satellite signals of any strength.

It is further an advantage of the invention that it
requires no additional components in a communication
system transmitter of the device.

Preferred embodiments of the invention become apparent
from the dependent claims.

The invention can be employed in any device comprising a
receiver. The receiver can be for example a satellite
positioning system receiver like a GPS receiver or a
Galileo receiver, but equally any other type of receiver.

The invention can be employed in particular, though not exclusively, in any device comprising a receiver and in addition a communication system transmitter. The communication system transmitter can be for example part of a GSM transceiver, of a US-TDMA transceiver, of a WCDMA-GSM transceiver or of a CDMA transceiver.

In case the invention is employed in a device comprising in addition a communication system transmitter, it can be used in particular for attenuating wideband noise generated by this communication system transmitter in the first frequency band. Wideband noise in the first frequency band can then be expected by the controlling portion at least whenever the communication system transmitter is known to be transmitting signals. The controlling portion may either be part of the communication system transmitter or receive a corresponding information about transmissions from the communication system transmitter. It has to be noted, however, that the invention can equally be employed for attenuating wideband noise generated by a unit external to the device.

In an advantageous embodiment, the receiver comprises at least a first receiving chain for receiving and processing radio frequency signals in the first frequency band and a second receiving chain for receiving and processing radio frequency signals in the second frequency band. In this embodiment, the first antenna is connected to the first receiving chain and in addition via a switching component to the second receiving chain. The controlling portion can then cause the switching

component to connect the first antenna in addition to the second receiving chain, whenever a wideband noise is expected in the first frequency band. Thereby, the performance of the receiver can be improved, as signals may be available for evaluation at the second frequency band while the signals at the first frequency band are being disturbed by wideband noise.

In case the receiver comprises two receiving chains, the device according to the invention comprises advantageously in addition a second antenna, which has a frequency response at the second frequency band and which is equally connected via the switching component to the second receiving chain. The second antenna can be used for a diversity reception improvement in the receiver. The controlling portion may then cause the switching component to disconnect the second antenna from the second receiving chain, whenever the first antenna is connected via the switching component to the second receiving chain since a wideband noise is expected in the first frequency band.

In such a device, the controlling portion advantageously further causes the switching component to connect the first antenna to the second receiving chain and to disconnect the second antenna from the second receiving chain, in case a wideband noise is expected in the second frequency band.

The noise in the second frequency band can be generated for example by a second communication system transmitter of the device, which transmits signals via a radio interface in a different frequency band than the first

communication system transmitter of the device. In this
case, wideband noise in the second frequency band can be
expected by the controlling portion at least whenever the
second communication system transmitter is known to be
transmitting signals.

BRIEF DESCRIPTION OF THE FIGURES

Other objects and features of the present invention will
become apparent from the following detailed description
considered in conjunction with the accompanying drawing.

Fig. 1   illustrates the modulation of GPS carrier
          frequencies;

Fig. 2   is a schematic block diagram of a mobile phone, in
          which a first embodiment of the invention is
          implemented;

Fig. 3   is a diagram illustrating the operation of the
          first embodiment of the invention;

Fig. 4   is a schematic block diagram of a mobile phone, in
          which a second embodiment of the invention is
          implemented;

Fig. 5   is a diagram illustrating the operation of the
          second embodiment of the invention;

Fig. 6a and 6b are a further diagrams illustrating the
          operation of the second embodiment of the
          invention;

Fig. 7   is a schematic block diagram of a mobile phone, in
          which a third embodiment of the invention is
          implemented; and

Fig. 8a and 8b are diagrams illustrating the operation of
          the third embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Figure 2 is a schematic block diagram of a mobile phone
20, in which a first embodiment of the invention is
implemented. Only selected components of the mobile phone
20 are depicted.

The mobile phone supports a GPS positioning and a mobile
communication via a GSM network.

For supporting the GPS positioning, the mobile phone 20
comprises a GPS receiver 21. The GPS receiver 21
includes, connected to each other in series, a low noise
amplifier LNA 211, a mixer 212, a variable gain
attenuator 213 and a converters and DSP (digital signal
processor) processor block 214. A local oscillator 215 is
connected in addition to the mixer 212. The local
oscillator 215 provides a signal having a frequency
required for downconverting an L1 signal. The mobile
phone 20 further comprises a GPS antenna 216 which is
connected via a tuning component 217 to the low noise
amplifier 211 of the GPS receiver 21. The tuning
component 217 comprises a detuning circuitry, e.g. a
capacitance diode, for tuning the frequency band which
can be received via the GPS antenna 216.

For supporting the mobile communication, the mobile phone
20 comprises a GSM1800 transmitter 22, which is part of a
GSM1800 transceiver. The transmitter 22 comprises,
connected to each other in series, a converters and DSP
processor block 221, a first variable power amplifier
222, a mixer 223 and a second variable power amplifier

224. The transmitter 22 further comprises a local
oscillator 225, which is connected to the mixer 223. The
mobile phone 20 moreover comprises a GSM antenna 226,
which is connected to the second variable amplifier 224.
The converters and DSP processor block 221 of the
transmitter 22 has a controlling access to the tuning
component 217.

A radio frequency signal reaching the mobile phone 20 is
received by the GPS antenna 216, in case the signal lies
within the frequency band of the frequency response of
the GPS antenna 216. The tuning component 217 is able to
switch the frequency response of the GPS antenna 216
between two different frequency bands, one of which is
the GPS L1 frequency band. A radio frequency signal
received via the GPS antenna 216 is processed by the GPS
receiver 21. More specifically, the received signal is
amplified by the LNA 211 and mixed by the mixer 212 with
a signal provided by the local oscillator 215. In case
the received signal is an L1 signal, the mixing results
in a down-conversion to the base band. The downconverted
signal is then attenuated or amplified by the variable
gain attenuator 213 with a gain currently set by an AGC
(automatic gain control), and finally processed in a
conventional way in the converters and DSP processor
block 214. The processing in the converters and DSP
processor block 214 may comprise for instance determining
and tracking a C/A-code in the signal, decoding a
navigation information comprised in the tracked signal
and performing positioning calculations for determining
the current position of the mobile phone 20.

A signal, which is to be transmitted by the GSM
transmitter 22 in the scope of a mobile communication to
a base station, is processed for transmission in a
conventional way by the GSM transmitter 22. The signal is
provided by the converters and DSP processor block 221 to
the first variable power amplifier 222, which amplifies
the signal with a currently set amplification factor. The
amplified signal is then mixed by the mixer 223 with a
signal provided by the local oscillator 225 for an up-
conversion to a radio frequency signal. The radio
frequency signal is further amplified by the second
variable power amplifier 224 with a currently set
amplification factor. The amplification factors are set
by an AGC according to a request by the base station of a
communication network to which the mobile phone 20 is
currently connected. The signal output by the second
variable power amplifier 224 is then transmitted via the
GSM antenna 226.

The detuning of the GPS antenna 216 to another frequency
band by the tuning component 217 will be explained in
more detail in the following with reference to figure 3.
Figure 3 is a diagram which depicts on a frequency line
the GSM1800 TX band of 1710-1785 MHz, the GPS L1 band of
1570.30-1580.53 MHz, the GPS L2 band around 1227 MHz, the
GPS L5 band around 1176.45 MHz and the GSM900 TX band of
880-925 MHz.

In a first state, the GSM transmitter 22 does not
transmit any signals. In this first, basic state, the GPS
antenna 216 is tuned by the tuning component 217 to
receive satellite signals in the GPS L1 frequency band of

1570.30 MHz to 1580.53 MHz. The corresponding GPS antenna frequency response is shown as a first curve in figure 3.

In a second state, the GSM transmitter 22 transmits signals having a carrier frequency in the range of 1710-1785 MHz, causing wideband noise in the GPS L1 frequency band of 1575.42 MHz +/-5 MHz. The distribution of the power level of transmitted GSM1800 signals over the frequency is depicted as second curve in figure 3. The generated wideband noise is superimposed on any satellite signal reaching the GPS antenna 216. The wideband noise degrades the performance of the GPS receiver 21, in case it reduces the SNR of received GPS L1 satellites signals below an acceptable value.

When the GSM transmitter 22 transmits signals with a power level exceeding a predetermined low power level, the converters and DSP processor block 221 of the GSM transmitter 22 therefore provides a control signal to the tuning component 217. Thereupon, the tuning component 217 detunes the GPS antenna 216 to somewhat lower or higher frequencies. The resulting shifted GPS antenna frequency response is depicted as third curve in figure 3 in the case the frequency is tuned to a lower frequency.

With the shifted GPS antenna frequency response, the antenna isolation between the GSM antenna 226 and the GPS antenna 216 is improved, as indicated by a double headed arrow in figure 3. When a GPS signal reaching the mobile phone 20 is strong, and has thus a rather high SNR in spite of the superimposed wideband noise, the signal received via the GPS antenna 216 may be strong enough for a detection even though the GPS antenna 216 is detuned.

When a GPS signal reaching the mobile phone 20 is weak,
however, and has thus a rather low SNR due to the
superimposed generated wideband noise, the signal
received via the GPS antenna 216 is not strong enough for
a detection, and thus errors in the evaluation in the
converters and DSP processor block 214 are prevented.
Therefore, the increased attenuation between the GSM
antenna 226 and the GPS antenna 216 that the GSM
transmitter 22 eases the performance degradation of the
GPS receiver 21.

It is also possible to relate the amount of detuning to
the extend of the respective amplification applied by GSM
transmitter 22 to signals which are to be transmitted.

A second and a third embodiment of the invention, which
will be presented further below, take into account
planned future developments of GPS.

The second embodiment of the invention is based on the
assumption that in addition to the C/A-code of the L1
signal, also the P-code of the L1 signal and the L2
signal including a C/A code and a P-code are taken into
civil usage.

Figure 4 is a schematic block diagram of a mobile phone
40, in which the second embodiment of the invention is
implemented. As in figure 2, only selected components of
the mobile phone 40 are depicted.

The mobile phone 40 of figure 4 supports again a GPS
positioning and a mobile communication via a GSM network.

For supporting a GPS positioning, the mobile phone 40 of
figure 4 comprises a GPS receiver 41. The GPS receiver 41
includes a first receiving chain 43 for receiving and
processing L1 signals and a second receiving chain 44 for
receiving and processing L2 signals. The L1 receiving
chain 43 comprises, connected to each other in series, a
first low noise amplifier LNA 431, a first mixer 432 and
a first variable gain attenuator 433. The L1 receiving
chain 43 further comprises a first local oscillator 435,
which is connected to the first mixer 432. The first
local oscillator provides a signal having a frequency
which is required for downconverting an L1 signal. The L2
receiving chain 44 comprises, connected to each other in
series, a second low noise amplifier LNA 441, a second
mixer 442 and a second variable gain attenuator 443. The
L2 receiving chain 44 further comprises a second local
oscillator 445, which is connected to the second mixer
442. The second local oscillator 445 provides a signal
having a frequency which is required for downconverting
an L2 signal. The GPS receiver 41 comprises in addition a
converters and DSP processor block 414. The first
variable gain attenuator 433 of the L1 receiving chain 43
and the second variable gain attenuator 443 of the L2
receiving chain 44 are both connected to this converters
and DSP processor block 414.

For supporting a GPS positioning, the mobile phone 40
moreover comprises a GPS antenna 416. The GPS antenna 416
is connected by means of an enhanced diplexer 417 on the
one hand to the first low noise amplifier 431 of the L1
receiving chain 43 and on the other hand via a switch 418
to the second low noise amplifier 44 of the L2 receiving

chain 44. Typically, a diplexer combines two input path
signals having different frequencies to one output path
signal. The enhanced diplexer 417 comprises a detuning
circuitry and diplexer functionalities. The detuning
function can be done with a capacitance diode or any
other suitable component. The detuning circuitry tunes
the frequency band, which can be received via the GPS
antenna 416.

For supporting a mobile communication, the mobile phone
40 comprises a GSM1800 transmitter 42, which is part of a
GSM1800 transceiver. The transmitter 42 comprises a
converters and DSP processor block 421, a first variable
power amplifier 422, a mixer 423 and a second variable
power amplifier 424. The transmitter 42 further comprises
a local oscillator 425 which is connected to the mixer
423. The mobile phone 40 further comprises a GSM antenna
426, which is connected to the second variable amplifier
424. The converters and DSP processor block 421 has in
addition a controlling access to the diplexer 417 and the
switch 418.

For supporting a mobile communication, the mobile phone
40 may comprise in addition a GSM900 transmitter (not
shown), which is part of a GSM900 transceiver and
designed similarly as the GSM1800 transmitter.

Transmissions via the GSM1800 transmitter and a GSM900
transmitter take place as described above with reference
to figure 2 for the GSM1800 transmitter.

While the GSM1800 transmitter 42 is not transmitting any
signals, the GPS antenna 426 is connected via the

diplexer 417 only to the L1 receiver chain 43. The GPS
antenna 416 is in resonance at the center frequency of
the L1 frequency band, and received L1 signals are
forwarded to the L1 receiver chain 43 and processed as
described above with reference to figure 2.

When the GSM1800 transmitter 42 is transmitting signals,
wideband noise is generated in the L1 frequency band. The
converters and DSP processor block 421 therefore provides
a control signal to the switch 418, which causes the
switch 418 to be closed. As a result, signals received by
the GPS antenna 416 are provided to both, the L1 and the
L2 receiving chain 43, 44. At the same time, the
converters and DSP processor block 421 provides a control
signal to the diplexer 417, which causes the detuning
circuitry in the diplexer 417 to detune the GPS antenna
416 to be in resonance at the center frequency of the L2
frequency band.

The shift of the GPS antenna frequency response is
illustrated in figure 5. Figure 5 is a diagram which
corresponds to the diagram of figure 3, except that here,
the GPS antenna frequency response was shifted exactly to
the L2 frequency band. The resulting improvement of the
isolation between the GPS antenna 416 and the GSM antenna
426 is rather high, as indicated by a double-headed arrow
in figure 5.

Due to the specific detuning in the second embodiment of
the invention, a good reception of the L2 frequency band
by the GPS antenna 416 and thus a good reception of the
L2 band C/A and P-code in the L2 receiving chain 44 is
achieved. From the L1 band, the C/A-code and the P-code

can still be received in some conditions via the L1
receiving chain 43, that is, if the L1 signal reaching
the mobile phone is particularly strong. In case of a
strong L1 carrier signal, also the SNR of the L1 signal
will be sufficiently strong for an evaluation in spite of
the wideband noise.

Figures 6a and 6b illustrate the detuning in another type
of representation. In figure 6a, the insertion loss S_{11} in
dB of the GPS antenna 416 is depicted over the frequency
for the case that there is no GSM1800 transmission. It
can be seen that the insertion loss S_{11} is in general at a
basically constant, high value, but decreases to a
minimum value at a center frequency of 1575 MHz with a
transition range on both sides of this center frequency.
This enables a good reception of the L1 band C/A-code and
the L1 band P-code in the L1 receiver chain 43. The L2
receiver chain 44 is not in use. The GSM1800 transceiver
may receive signals at the same time, and if the mobile
phone 40 comprises in addition a GSM900 transceiver, the
GSM900 transceiver may receive or transmit signals at the
same time, as such operations do not generate any
wideband noise in the L1 frequency band.

In figure 6b, the insertion loss S_{11} in dB of the GPS
antenna 416 is depicted over the frequency for the case
that there is an ongoing GSM1800 transmission. It can be
seen that the insertion loss S_{11} is in general at a
basically constant, high value, but decreases to a
minimum value at a shifted center frequency of 1227 MHz
with a transition range on both sides of this center
frequency. This enables a good reception of the L2 band
P-code in the L2 receiver chain 44. At the same time, the

wideband noise generated by the GSM1800 transmission is attenuated.

The same result as for the European bands GSM1800 and GSM900 depicted in figures 6a and 6b can be achieved for the U.S. bands GSM1900 and GSM850.

The third embodiment of the invention is based on the assumption that in addition to the C/A-code of the L1 signal, also the P-code of the L1 signal and of the L2 signal and a newly introduced C/A-code of the L2 signal are taken into civil usage.

Figure 7 is a schematic block diagram of a mobile phone 70, in which the third embodiment of the invention is implemented. As in figures 2 and 4, only selected components of the mobile phone 70 are depicted.

The mobile phone 70 of figure 7 supports again a GPS positioning and a mobile communication via a GSM network. The C/A-code and the P-code of the L2 band are made use of in the GPS positioning for a diversity reception improvement.

The design of the mobile phone 70 of figure 7 is very similar to the design of the mobile phone of figure 4.

For supporting a GPS positioning, the mobile phone 70 of figure 7 thus comprises a GPS receiver 71. The GPS receiver 71 includes a first receiving chain 73 for receiving and processing L1 signals and a second receiving chain 74 for receiving and processing L2 signals. The L1 receiving chain 73 comprises, connected

to each other in series, a first low noise amplifier LNA
731, a first mixer 732 and a first variable gain
attenuator 733. The L1 receiving chain 73 further
comprises a first local oscillator 735, which is
connected to the first mixer 732. The first local
oscillator provides a signal having a frequency which is
required for downconverting an L1 signal. The L2
receiving chain 74 comprises, connected to each other in
series, a second low noise amplifier LNA 741, a second
mixer 742 and a second variable gain attenuator 743. The
L2 receiving chain 74 further comprises a second local
oscillator 745, which is connected to the second mixer
742. The second local oscillator 745 provides a signal
having a frequency which is required for downconverting
an L2 signal. The GPS receiver 41 comprises in addition a
converters and DSP processor block 714. The first
variable gain attenuator 733 of the L1 receiving chain 73
and the second variable gain attenuator 743 of the L2
receiving chain 74 are both connected to this converters
and DSP processor block 714.

For supporting a GPS positioning, the mobile phone 70
moreover comprises a first GPS antenna 716 and a second
GPS antenna 719. The first GPS antenna 716 is connected
by means of an enhanced diplexer 717 on the one hand to
the first low noise amplifier 731 of the L1 receiving
chain 73 and on the other hand via a switch 718 to the
second low noise amplifier 741 of the L2 receiving chain
74. The enhanced diplexer 717 comprises a detuning
circuitry for tuning the frequency band which can be
received via the first GPS antenna 716 from the L1
frequency band to the L2 frequency band. The second GPS
antenna 719 is connected equally via the switch 718 to

the second low noise amplifier 741 of the L2 receiving
chain 74. The second GPS antenna 719 is tuned in a fixed
manner to the L2 frequency band. The switch 718 allows to
connect either the first GPS antenna 716 or the second
GPS antenna 719 to the second GPS receiving chain 74.

For supporting a mobile communication, the mobile phone
70 comprises a GSM1900 transmitter 72, which is part of a
GSM1900 transceiver. The transmitter 72 comprises a
converters and DSP processor block 721, a first variable
power amplifier 722, a mixer 723 and a second variable
power amplifier 724. The transmitter 72 further comprises
a local oscillator 725 which is connected to the mixer
723. The mobile phone 70 further comprises a GSM antenna
726, which is connected to the second variable amplifier
724. The converters and DSP processor block 721 has in
addition a controlling access to the diplexer 717 and the
switch 718.

For supporting a mobile communication, the mobile phone
70 comprises in addition a GSM850 transmitter (not
shown), which is part of a GSM850 transceiver and
designed similarly as the GSM1900 transmitter.

Transmissions via the GSM1900 transmitter 72 or the
GSM850 transmitter are carried out as described above
with reference to figure 2 for the GSM1800 transmitter
22, only in other frequency bands.

While neither the GSM1900 transmitter 72 nor the GSM850
transmitter is transmitting signals, the first GPS
antenna 716 is connected via the diplexer 717 only to the
first GPS receiver chain 73. At the same time, the second

GPS antenna 719 is connected via the switch 718 to the second GPS receiver chain 74. The first GPS antenna 716 is in resonance at the L1 frequency band, and received L1 signals are forwarded to the first GPS receiver chain 73 and processed analogously as described above with reference to figure 2. The second GPS antenna 719 is in resonance at the L2 frequency band, and received L2 signals are forwarded to the second GPS receiver 74 chain and processed analogously as described above with reference to figure 2. The GSM1800 transceiver and the GSM900 transceiver may be receiving signals at the same time.

This first situation is illustrated in figure 8a, in which the insertion loss S_{11} in dB of both GPS antennas 716, 719 is depicted over the frequency for the case that there is no GSM transmission. At the first GPS antenna 716, the insertion loss S_{11} is in general at a basically constant, high value, but decreases to a minimum value at a center frequency of 1575 MHz with a transition range on both sides of this center frequency. This enables a good reception of the L1 band C/A-code and P-code via the first GPS antenna 716 in the first GPS receiving chain 73. At the second GPS antenna 719, the insertion loss S_{11} is in general at a basically constant, high value, but decreases to a minimum value at a center frequency of 1227 MHz with a transition range on both sides of this center frequency. This enables a good reception of the L2 band C/A-code and P-code via the second GPS antenna 719 in the second GPS receiving chain 74.

When the GSM1900 transmitter 74 is transmitting signals, wideband noise is generated in the L1 frequency band. The

converters and DSP processor block 721 therefore provides
a control signal to the switch 718, which causes the
switch 718 to connect the diplexer 717 instead of the
second GPS antenna 719 to the second GPS receiving chain
74. Thereby, signals received by the first GPS antenna
716 are provided to both, the first and the second GPS
receiving chain 73, 74. The second GPS antenna 719 is now
disconnected. At the same time, the converters and DSP
processor block 721 causes the first GPS antenna 716 to
be detuned to be in resonance at the L2 frequency band.

This second situation is illustrated in figure 8b, in
which the insertion loss of the first GPS antenna 716 is
depicted over the frequency for the case that there is a
GSM1900 transmission. At the first GPS antenna 716, the
insertion loss S_{11} is in general at a basically constant,
high value, but decreases to a minimum value at a shifted
center frequency of 1227 MHz with a transition range on
both sides of this center frequency. This enables a good
reception of the L2 band C/A-code and P-code via the
first GPS antenna 716 in the second GPS receiving chain
74. The wideband noise generated by the GSM1900
transmission is thus attenuated. From the L1 band, the
C/A-code and the P-code can be received in some
conditions via the first GPS antenna 716 in the first GPS
receiving chain 73, that is, if the L1 satellite signal
reaching the mobile phone 70 is particularly strong. The
disconnected second GPS antenna 719 does not forward any
signals.

When the GSM850 transmitter is transmitting signals,
wideband noise is generated in the L2 frequency band. The
converters and DSP processor block (not shown) of the

GSM850 transmitter therefore provides a control signal to the switch 718, which causes the switch 718 to connect the diplexer 717 instead of the second GPS antenna 719 to the second GPS receiving chain 74. Thereby, signals received by the first GPS antenna 716 are provided to both, the first and the second GPS receiving chain 73, 74. The second GPS antenna 719 is now disconnected. The first antenna is kept to be tuned to be in resonance at the L1 frequency band.

This third situation is illustrated in figure 8c, in which the insertion loss S_{11} of the first GPS antenna 716 is depicted over the frequency for the case that there is a GSM850 transmission. At the first GPS antenna 716, the insertion loss S_{11} is in general at a basically constant, high value, but decreases to a minimum value at a center frequency of 1575 MHz with a transition range on both sides of this center frequency. This enables a good reception of the L1 band C/A-code and P-code via the first GPS antenna 716 in the second GPS receiving chain 74. The disconnected second GPS antenna 719 does not forward any signals. The wideband noise generated by the GSM850 transmission is thus attenuated. From the L2 band, the C/A-code and the P-code can be received in some conditions via the first GPS antenna 716 in the second GPS receiving chain 73, that is, if the L2 satellite signal reaching the mobile phone 70 is particularly strong.

It is to be understood that in the second and third embodiment, one of the GPS receiver chains or an additional GPS receiver chain could also be a receiver

chain for receiving GPS signals at the L5 band, if
suitable signals are transmitted at this band.

It is further to be noted that the described embodiments
constitute only three of a variety of possible
embodiments of the invention.